



CITY OF BISBEE SOLAR PROJECT

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THE PROFESSIONAL SCIENCE MASTERS — SOLAR ENERGY ENGINEERING AND COMMERCIALIZATION (PSM-SEEC) PROGRAM AT ASU

- One Year Masters graduate program
- Solar Engineering, Solar Business, Solar Policy
- The Students carry out an Applied Project in place of a Masters Thesis
- The Applied Project Committee has at least one faculty advisor and one industrial advisor
- The Applied Project is carried out for a client:
 - A Solar design company
 - A Solar EPC firm
 - A firm in the Electricity Business
 - A Municipality

PROBLEM STATEMENT

Climate change, increasing energy demands, and decreasing costs have made renewable energy sources more and more attractive

As a result, cities are leading the charge toward electricity usage produced by 100% renewable sources (ex: Aspen, CO and Burlington, VT)

The City of Bisbee wanted to follow suit so they reached out to ASU

This project will be focused on an 80-acre parcel of land (part of which will be an industrial park) close to the city airport and will represent the first step

UTILITY SCALE PLANNING

1. Determining the purpose
2. Site evaluation
3. Site assessment
4. Initial economic calculations
5. Survey of policy factors
6. Possible project risks
7. Community engagement

APPROACH

The solar farm was viewed as a possible solar-powered industrial park.

The design had to consider two embodiments: with and without battery storage

The modeling was done using two solar modeling programs: 1. System Advisor Model (SAM) developed by NREL for system energy and power performance and 2. Helioscope to produce layouts of the system

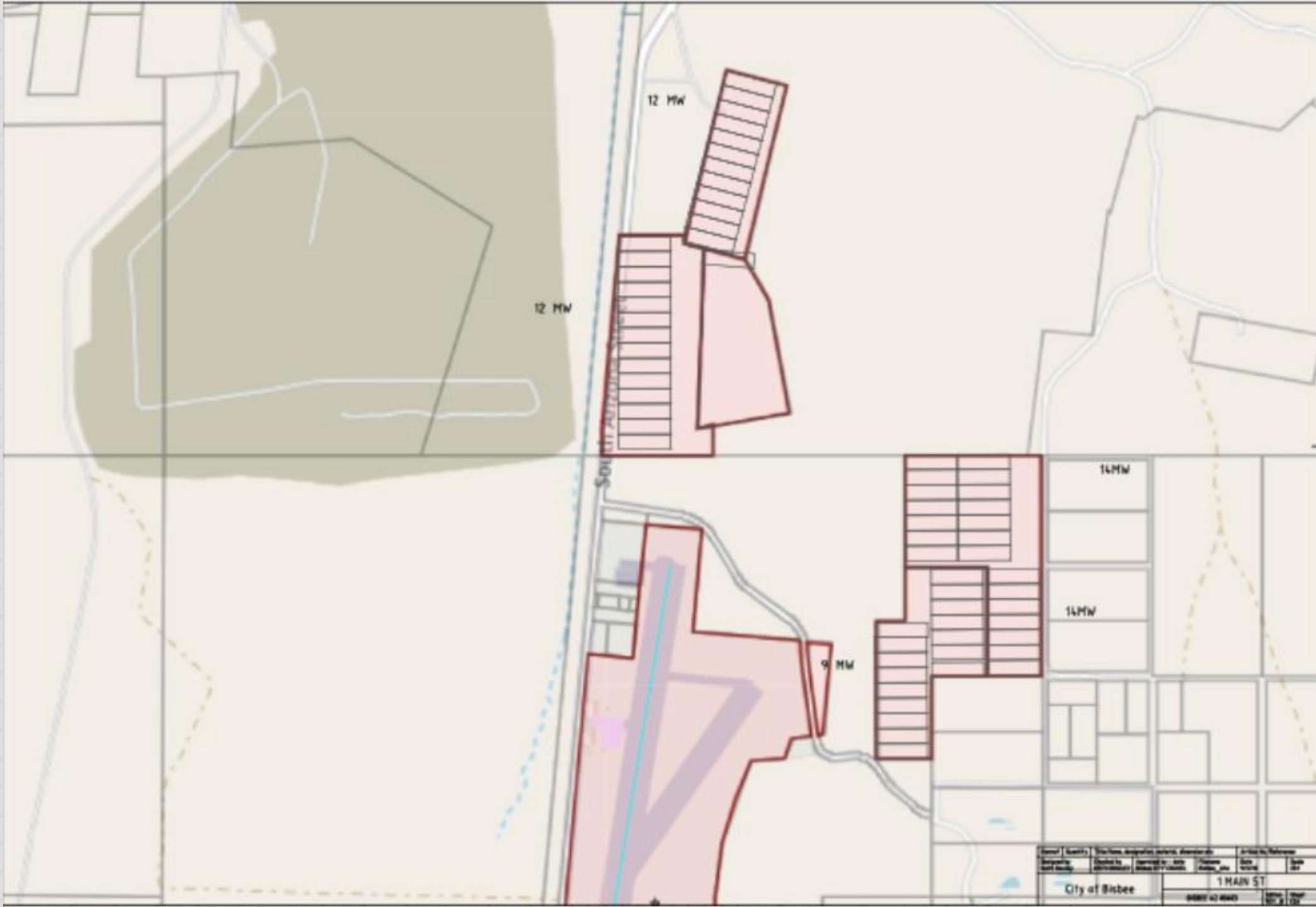
In addition a glare analysis was conducted, and the FAA form 7460-1 will have to be submitted for installation authorization

Various large scale electricity off-takers had to be identified

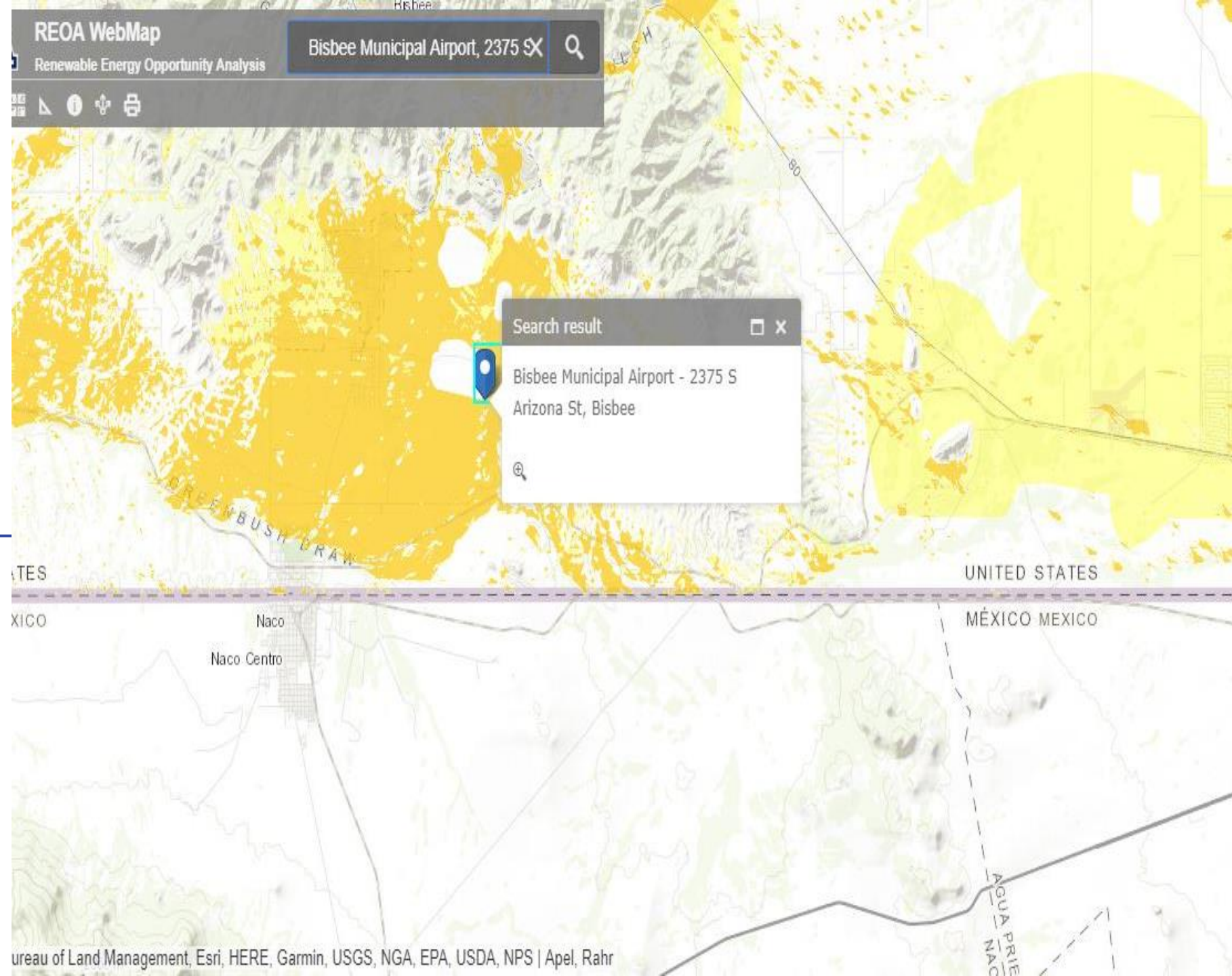
UTILITY SCALE PV SYSTEM DESIGN

Design Steps

1. Selecting an appropriate site and solving all land issues
2. Carrying out the permitting process for construction and operation
3. Selecting a financing approach including power purchase agreements or energy off-take agreements
4. Carrying out PV system and solar field engineering and design
5. Interconnection to the grid

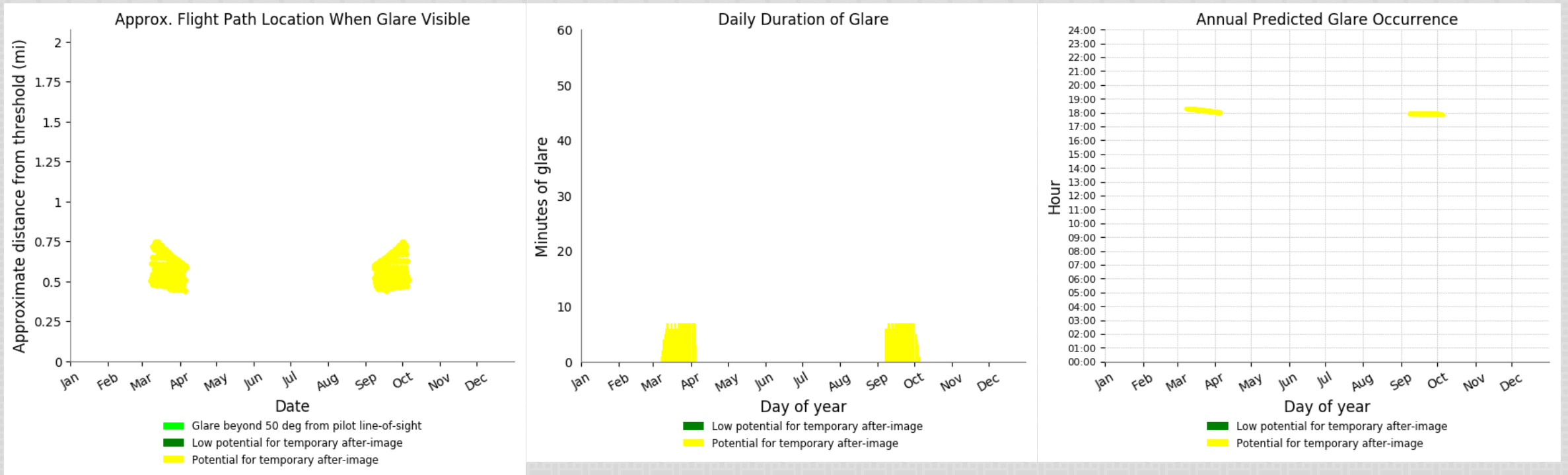


SOLAR RESOURCE

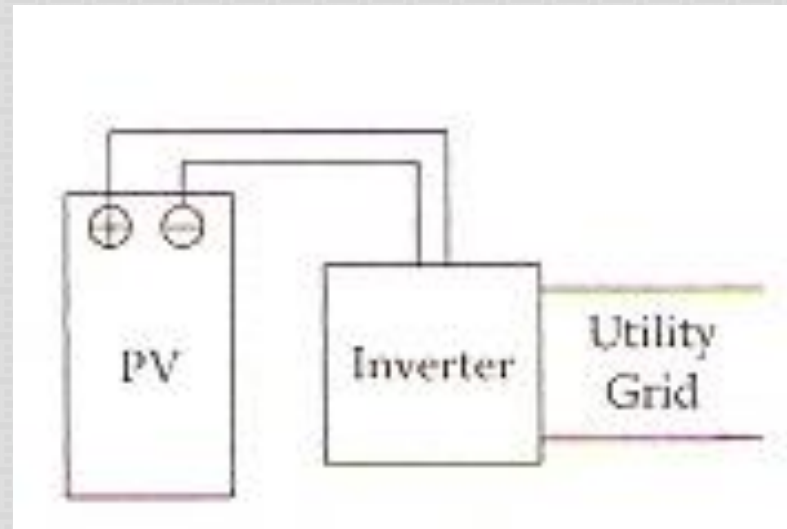


GLARE ANALYSIS

FAA requires no yellow flash from any flight path from airport threshold to 2 miles

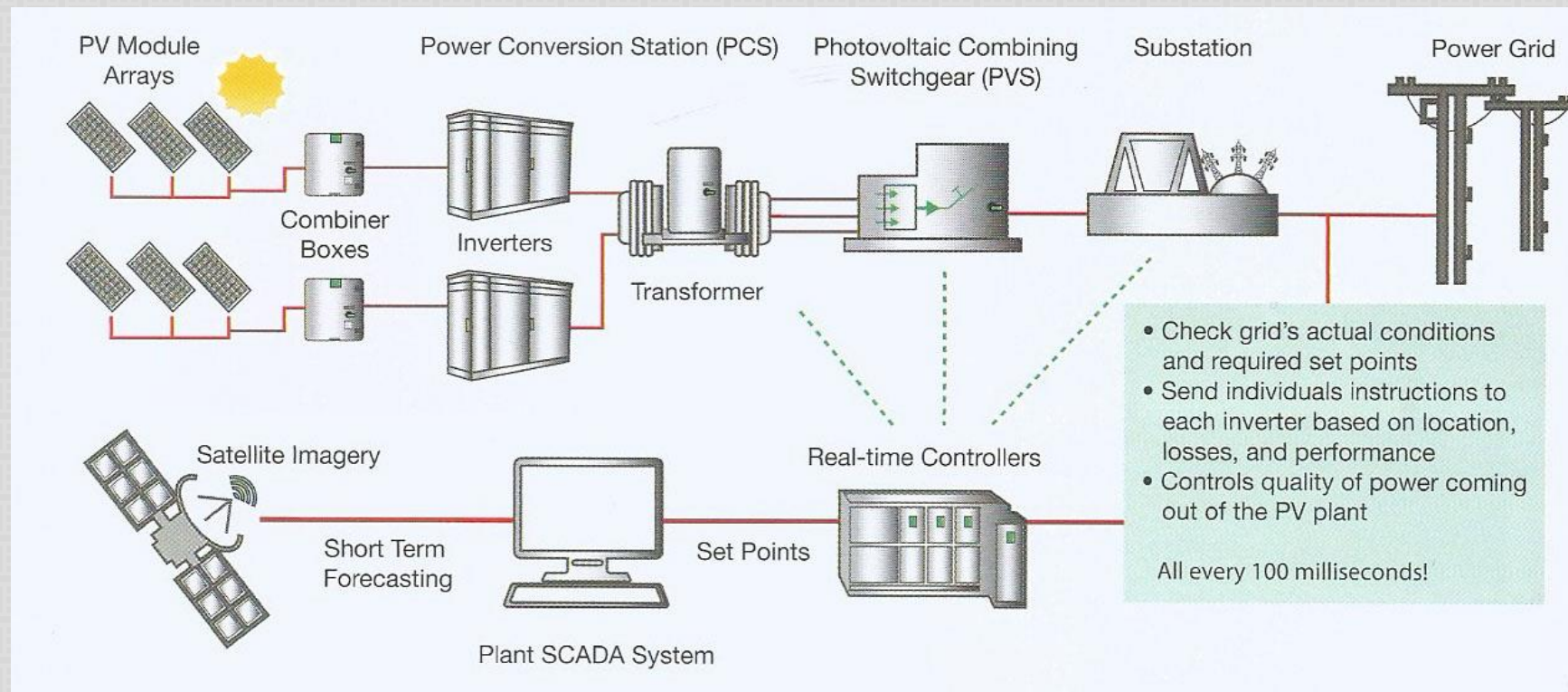


PV SYSTEM CONFIGURATION

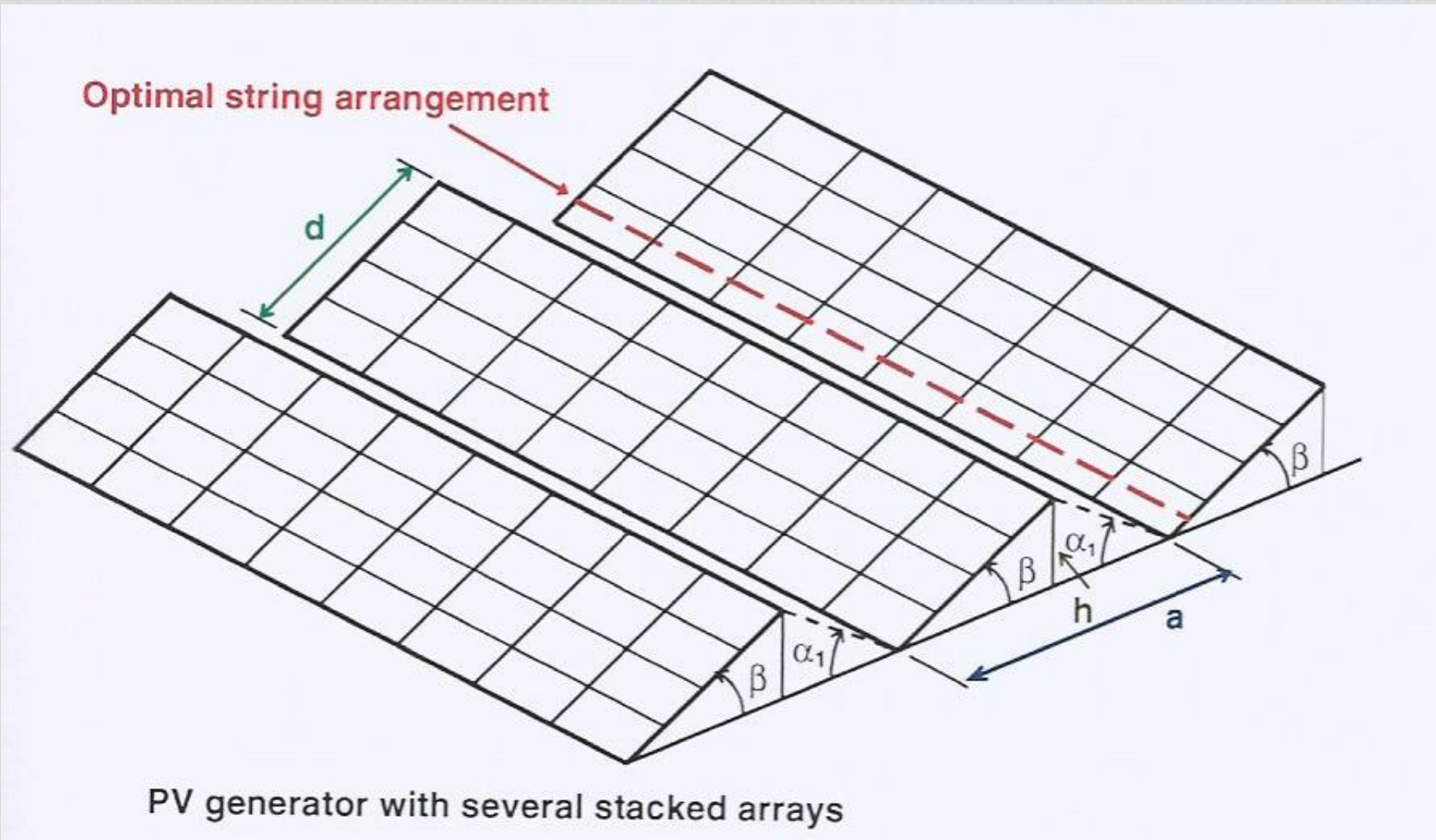


A simplified version of a “grid-tied” system that **changes the DC electrical energy to AC electrical energy and transmits that energy to the grid**

SOLAR FARM DESIGN – SYSTEM MONITORING



Solar Farm Design - Design calculations



**Shading
between rows**

INVERTER AND MODULE



ABB 1.5MW Inverter



335W Astronergy Module

THE SETUP

45000 modules and 10 inverters

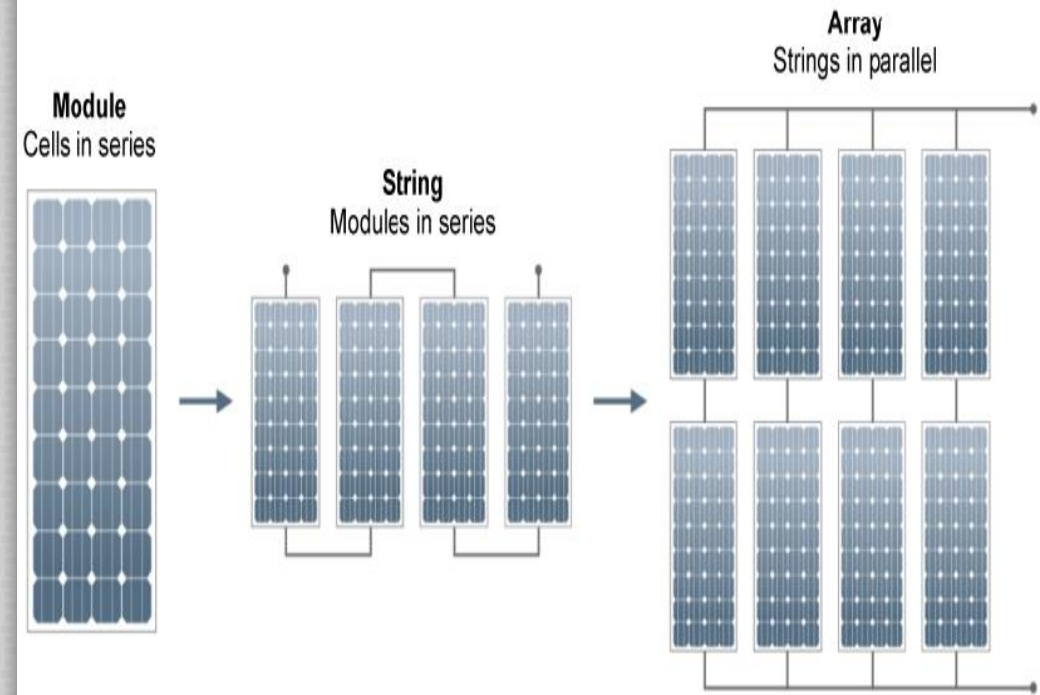
8 modules per string and 5,619 strings in parallel

2*12 modules per row for 1873 rows total

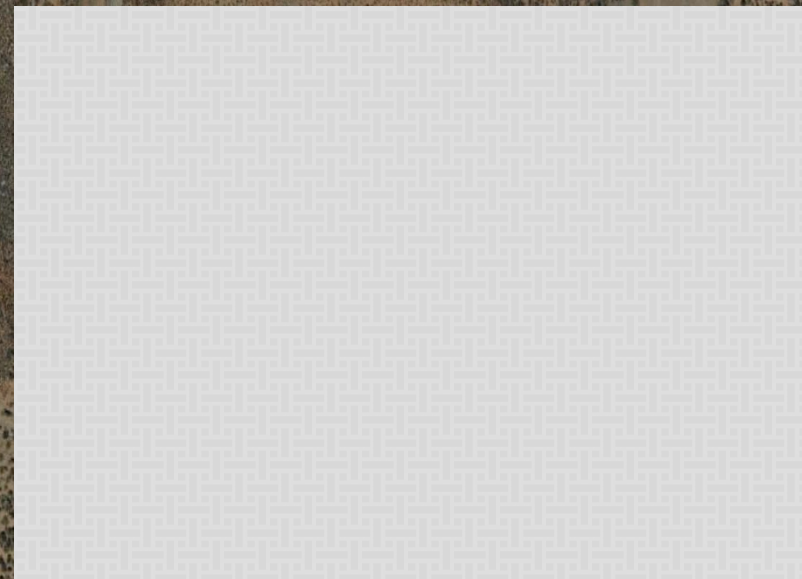
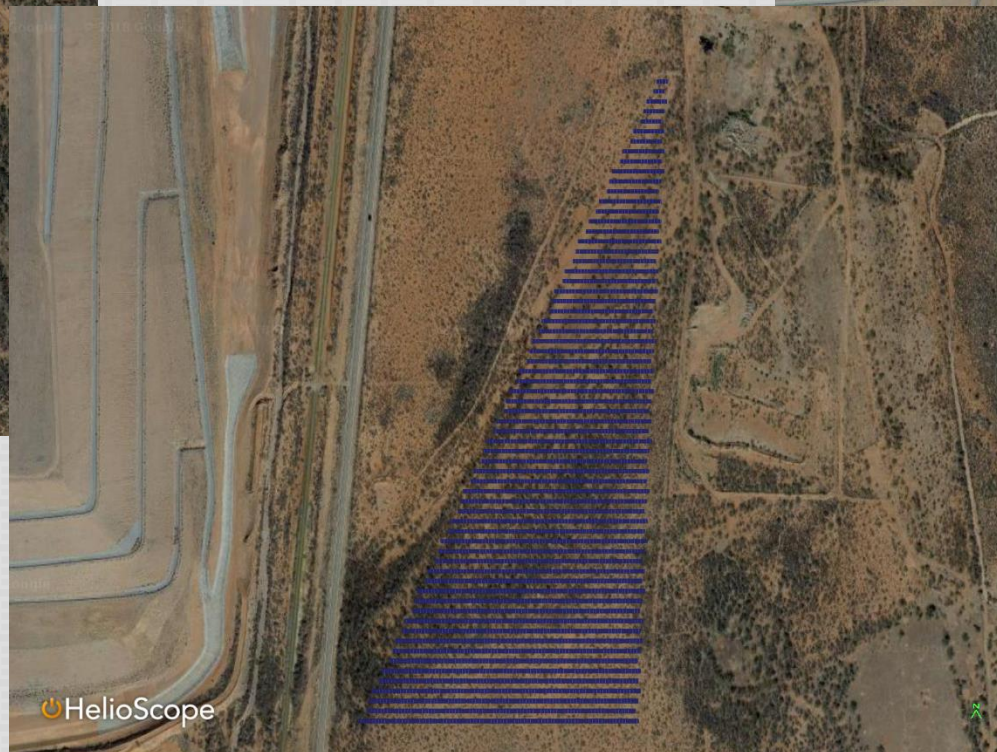
DC/AC ratio of 1.21

Total module area is 24 acres

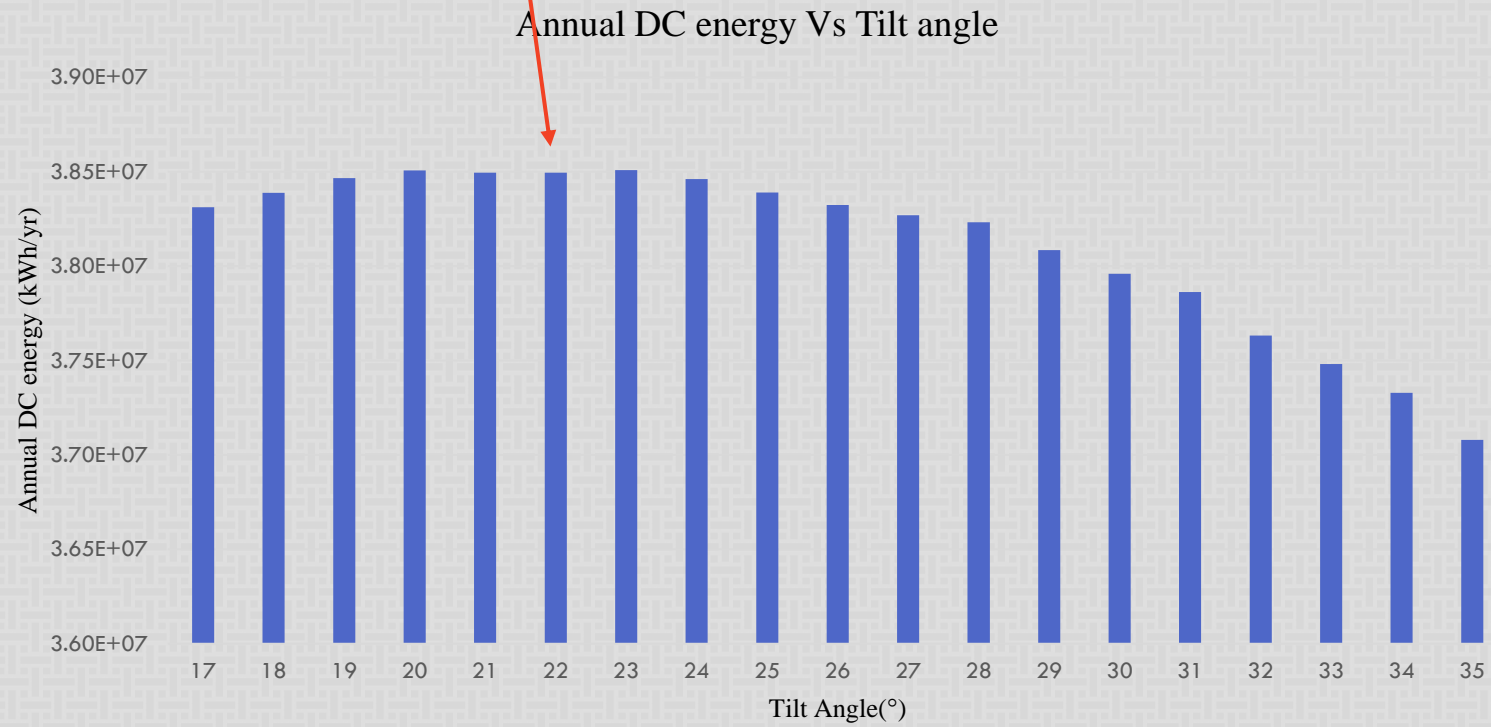
Fixed tilt and directed due south (180°)



LAYOUT



OPTIMAL TILT

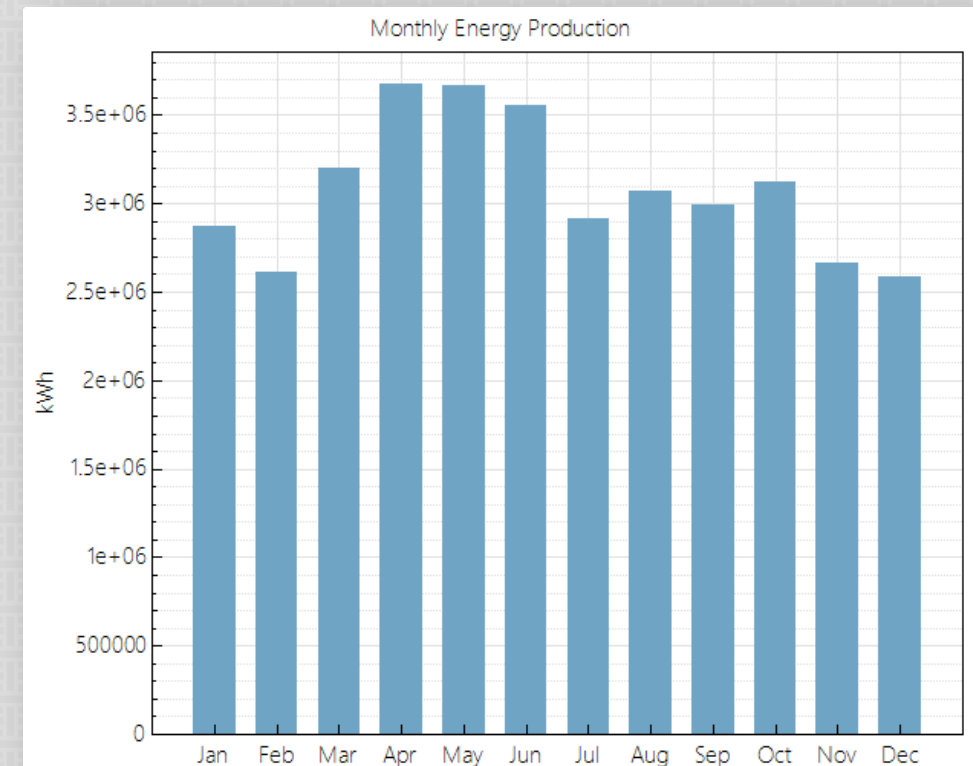
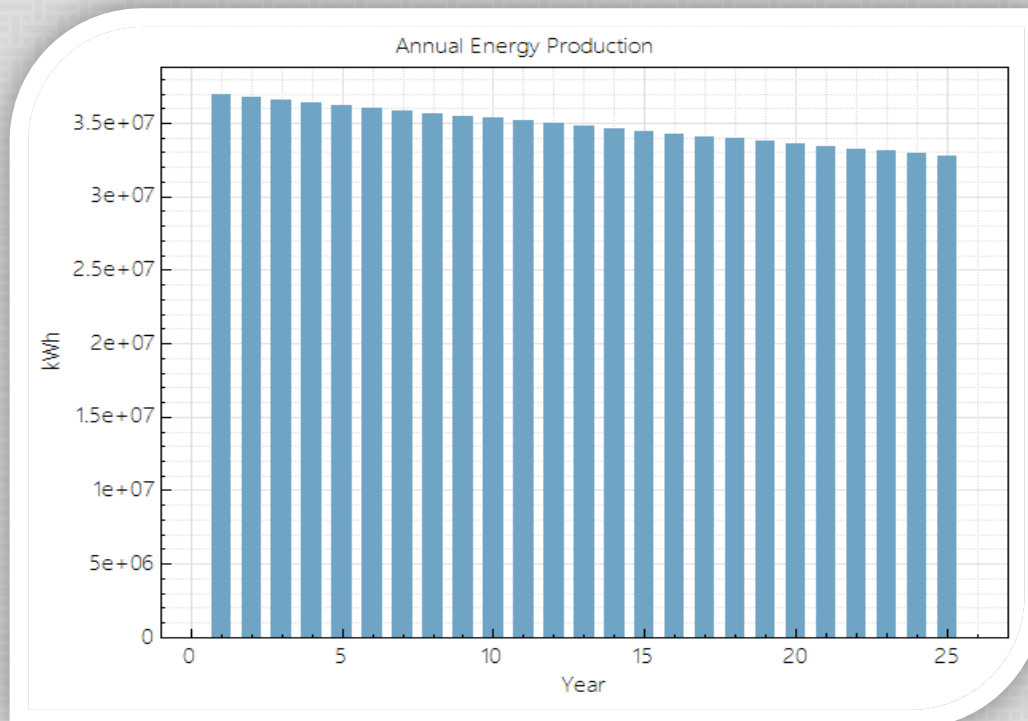


KEY RESULT OF THE DESIGN

- Using 40 of the available 80 acres for the solar farm, the farm could produce:
 - Peak power production of **20 MW**
 - Annual energy of **37 GWh** (37 million kWh)
 - Annual revenue-\$4.8M (13 cents/kWh)

DESIGN WITHOUT BATTERIES

Designed for 40, 30, 20, and 10 acres and the size proved to scale relatively linearly from 20, 15, 10, to 5MW respectively.



COST METRICS CALCULATED IN THE MODEL

- The Levelized Cost of Electricity (LCOE), the total cost divided by the total electricity over the life of the system is 5.63 cents/kWh
- Net Present Value of the farm is roughly \$3.6M
- The Internal Rate of Return (IRR) at the end of the project is approximately 14.8%.

COSTS ASSOCIATED WITH THE PROJECT

1) Module Cost

- Modules (335W) would be procured from Astronergy @ 36 cents per watt.
- The number of modules required is about 45000
- The on-ground cost would be about \$5.5M



COSTS ASSOCIATED WITH THE PROJECT

2) Inverter Cost

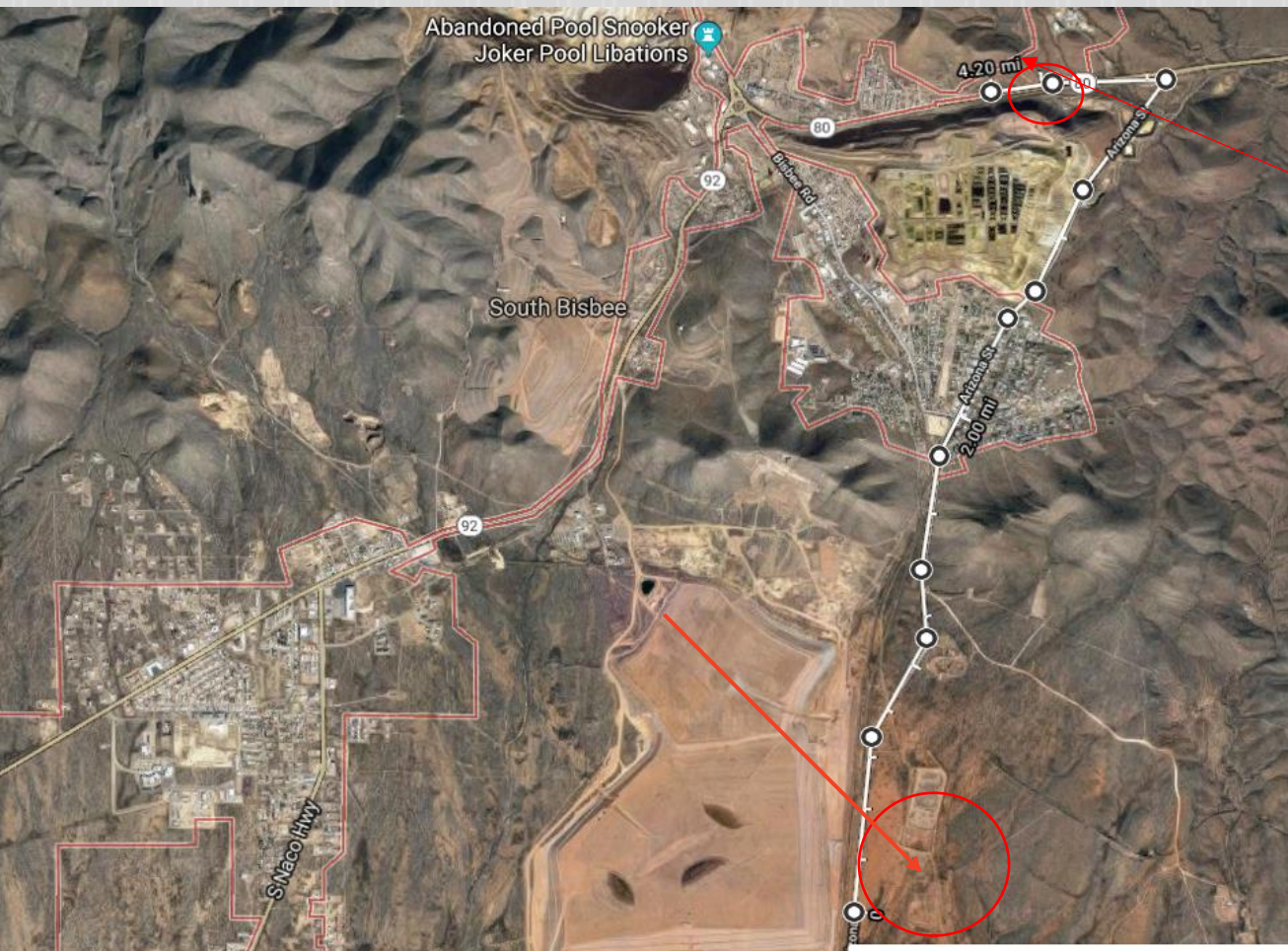
- ABB PVS 980 200kVA inverters would be procured.
- 10 inverters are required to meet the 20MW nominal peak power requirement
- The on-ground cost would be about \$1.5M



COSTS ASSOCIATED WITH THE PROJECT

- Balance of Systems
- Engineering
- Construction
- Application and
interconnection fees

Grand Total = \$21M
(\$1/W)



**DISTANCE FROM SITE TO NEAREST
SUBSTATION IS 4.2MI**

Our estimate: 20 poles to reach
the substation at \$3000/pole or
\$60,000 total

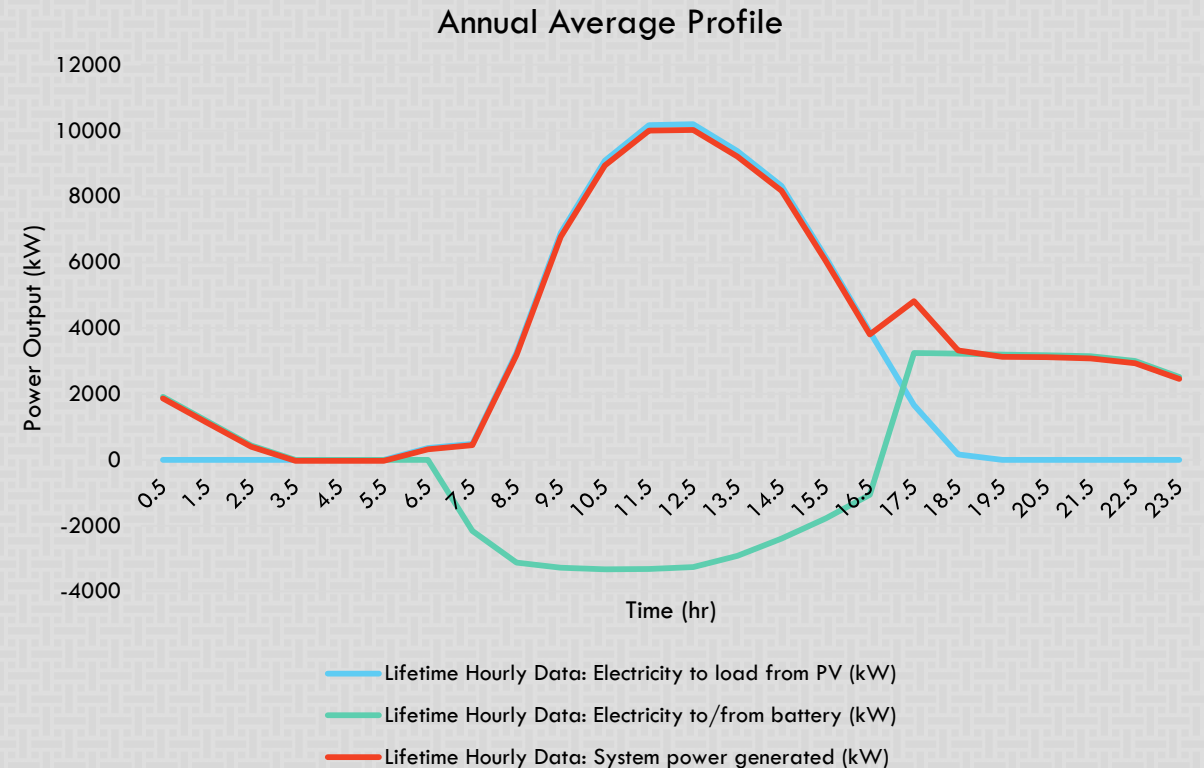
BATTERY MODELING

It is not economically viable to supply all the load with PV only

Although 4 hours of storage is typically used for a grid-connected system, an isolated system featuring uninterruptible power would require at least 14hrs of storage

This was examined in SAM, using Li-Ion batteries that could operate at an 80% depth of discharge.

$$3\text{MW} \times 14\text{hrs} = 42\text{MWh}$$



COSTS ASSOCIATED WITH THE PROJECT

3) **Battery cost**

- With an optimistic value of \$200/kWh cost for battery storage
- And with the modelled value of 42MWh battery capacity
- That makes the battery bank cost approximately **\$8.4M**

ENERGY OFF-TAKER, ANCHOR TENANT, POWER PURCHASE AGREEMENT

Options for an Anchor Tenant for the Business park

1. Call Center
2. Barley malting facility
3. A crypto-currency mining operation

CONTINUING THE LEGACY!!!

- Bisbee is well known for copper mining in the history.
- Perhaps it is time to move from 'hard-rock' mining to 'digital mining'.
- **Cryptocurrency mining**
 - There is at least one company that designs, installs, and runs a solar-powered operation



ANCHOR TENANT

Cryptocurrency mining: 962kWh per transaction, each (Antminer S9) machine consumes up to 1400W for 24hrs

Size anywhere between 40kW to 4MW

A 3MW PV system could power 2100 S9 machines and produce roughly 75 bitcoins/day



EthereumWorldNews

BUSINESS IDEAS FOR BISBEE

- At Solar Power International Conference 2018 in Anaheim we met Umining.
- Specialising in cryptocurrency mining using solar energy.
- They are looking for potential sites and developers and like minded people to host their sites and business.
- A win-win situation for everyone.
- The site could be break even in next 7-10 years, and then be a cash cow.
- Possibly, a worthy long-term investment.

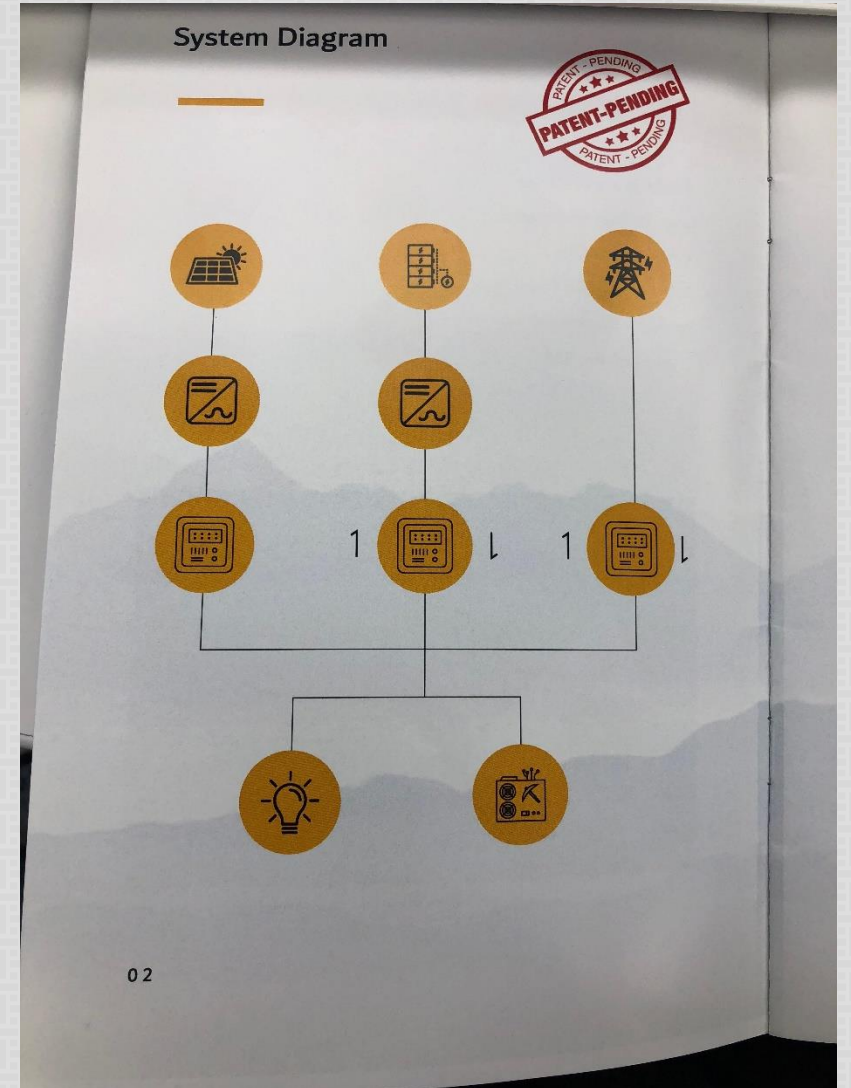


USOLAR

USolar is a crypto mining company based out of Santa Clara, California.

They primarily generate and use solar energy to power their data center for crypto mining.

Usolar = Solar + Storage + Cryptomining =
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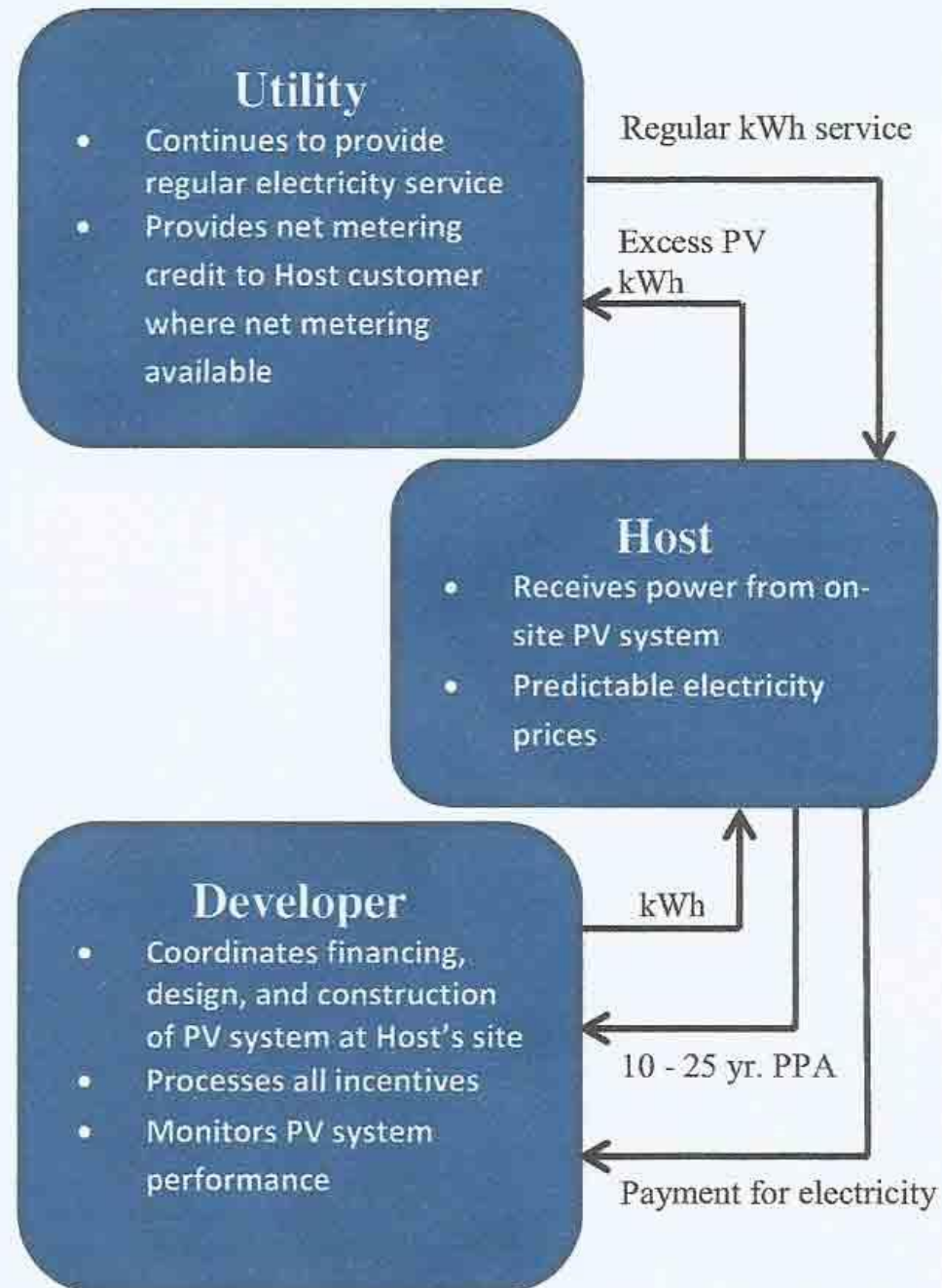


UTILITY SCALE PV SYSTEMS

The **Power Purchase Agreement** – Two versions

- A two party agreement in which one is a buyer of solar electrical power (the utility) and the other a seller of solar electrical power (the developer)
- A three party agreement with a developer of a PV system, a host customer, and a utility

Third Party PPAs (SEIA factsheet)



PROJECT EVALUATION

- The project has achieved its objectives of designing a solar farm with and without battery storage
- Battery storage for uninterruptible operation is almost certainly too expensive
- Financing methods such as PPAs will be essential for the project to move forward
- Carve out some of the solar farm power generation (5MW) to operate municipal operations, support other community needs

ADDITIONAL OPTIONS

APS Solar Communities Program (non-residential)

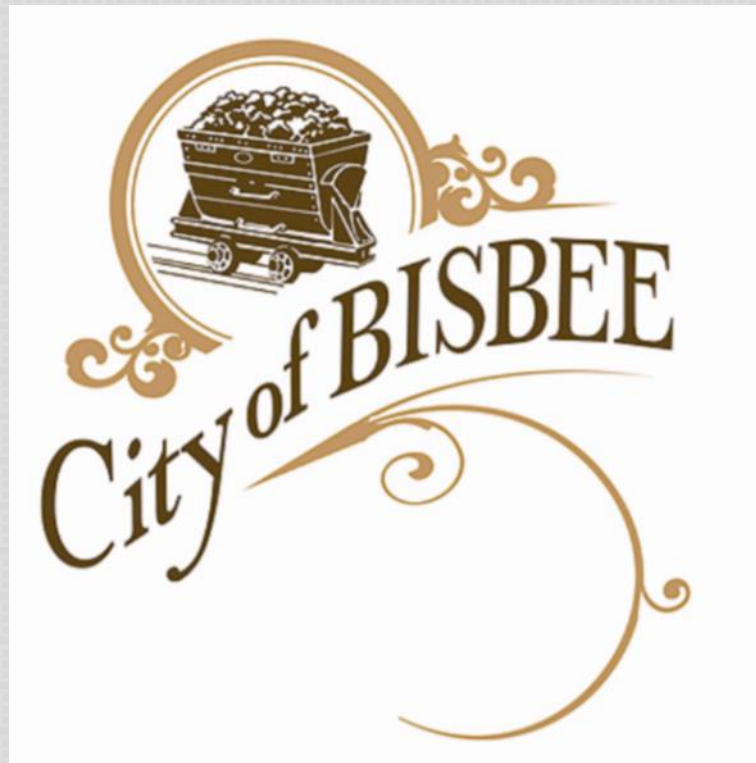
The APS Solar Communities program is open to non-residential customers that serve the limited income population, including Title I schools, nonprofits, rural governments and municipalities. Participation in the program is FREE and qualified non-residential customers will receive a solar-covered parking structure and a monthly bill credit on their energy bill. The program:

- Provides a free solar-covered parking structure on the non-residential property to be owned and maintained by APS for 20 years
- Provides annual savings off your APS electric bill for 20 years*
 - *bill credit will be valued based on the size of your parking structure solar system (\$2.5/kW)
- Is a FREE program with no cost to you
- Is open to non-residential customers who meet the following eligibility requirements:
 - Have enough outdoor space to accommodate a minimum 50kW size system (about 20 parking spots)
 - Does not have existing covered parking on-site
 - Serve APS limited-income customers

<https://www.aps.com/en/ourcompany/aboutus/investmentinrenewableenergy/Pages/aps-solar-communities.aspx>

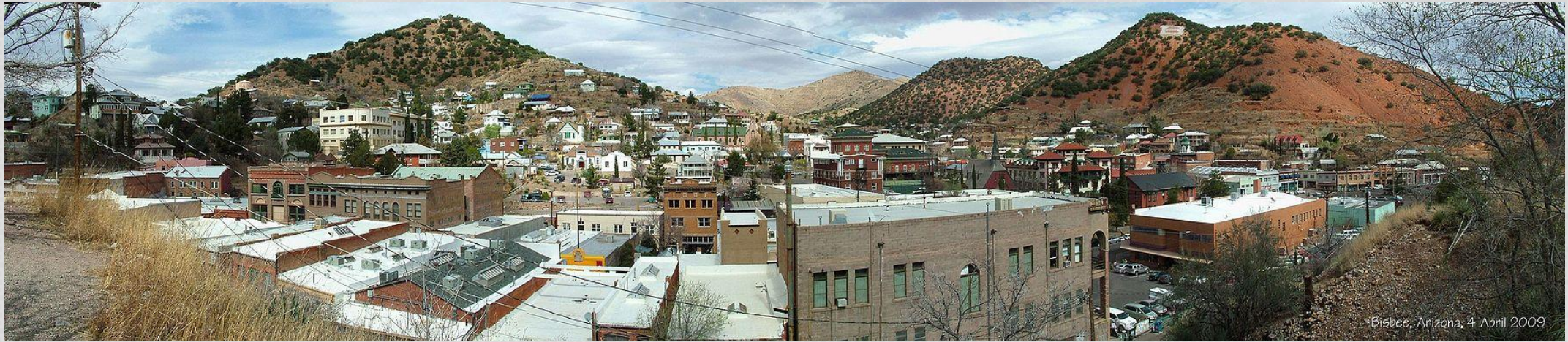


THANK YOU!!!



Keith Rowley
Solar NRG





SOLAR NRG CAPABILITIES AND OFFERINGS

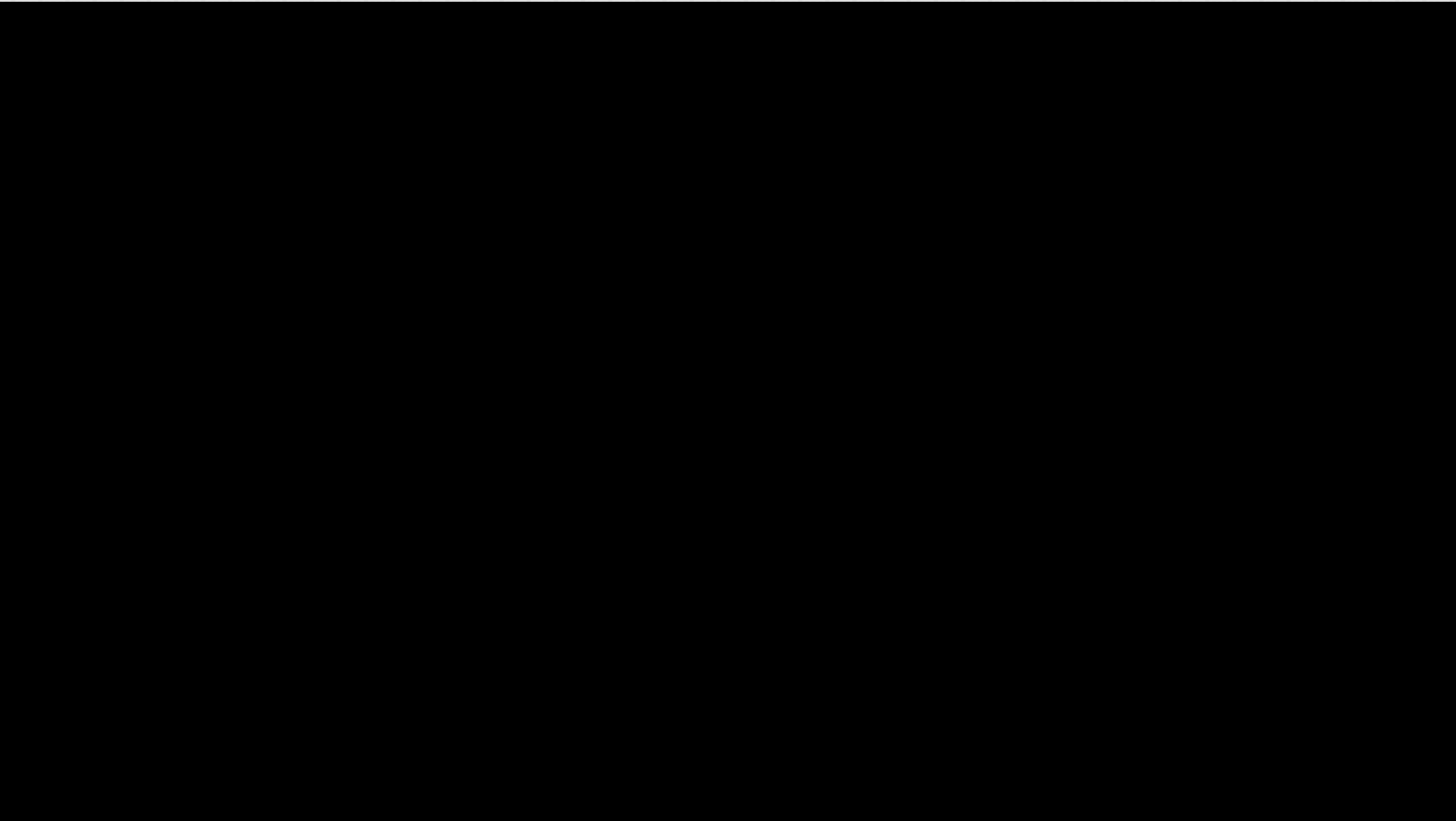
Performs full EPC and Project Management

Provides Full Ownership and Financing for first 5 years.

Completes on Schedule and on Budget

Provides Operations and Maintenance contract for full turn-key, smoothly as designed operation for years to come.

Has produced savings per year over \$4.810 M.



BISBEE WWTP VS. SOLAR FARM

No Production Based Incentives available anymore.

- Will have to make money by what system produces

Off-Taker of power

- Who uses and pays for power

Ownership

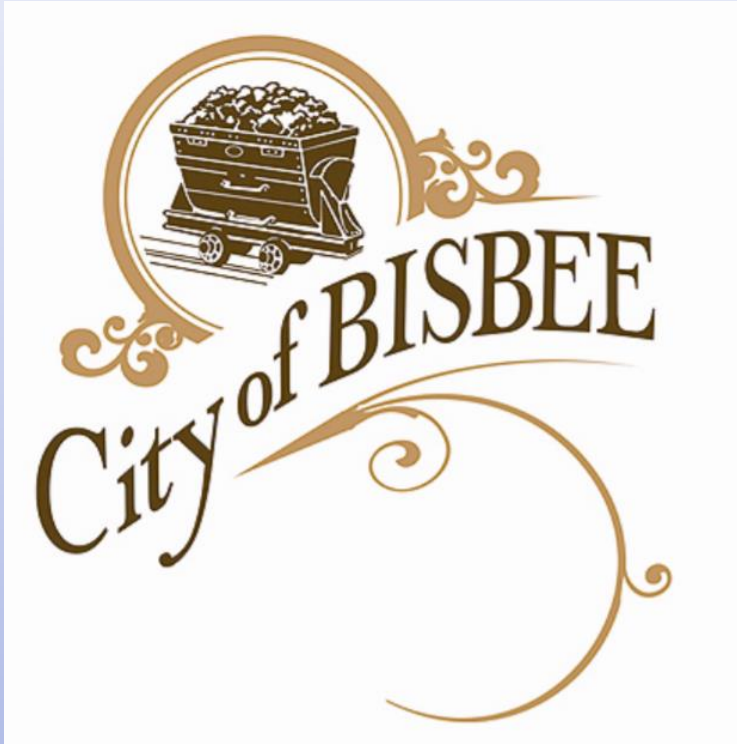
- Who and when is ownership transferred.

Care and feeding (O&M)

- Operations and Maintenance



OWNERSHIP OPTIONS FOR BISBEE SOLAR FARM



1. Purchase outright
2. Solar NRG sells Bisbee power forever at a discount.
3. Solar NRG owned model with purchase option at 6th year
 1. \$0 down
 2. Purchase after 5 years at “future fair market value”
 3. Pay for power generated for 5 years at slightly reduced cost/kWH
 4. After 5 years Owned by Bisbee
 5. Operations & Maintenance (O&M) contract included
4. Pass-through model
 1. Members of LLC take advantage of 30% Incentive Tax Credit (ITC)
 2. After 5 years solar system ownership transfers to City of Bisbee.

DEVELOPMENT PROJECT FLOWCHART

Sign
Contract

Engineering and
permit process

3 months

Utility
Design
Approval

1
2 months

Parts
Procurement

2 month

Installation

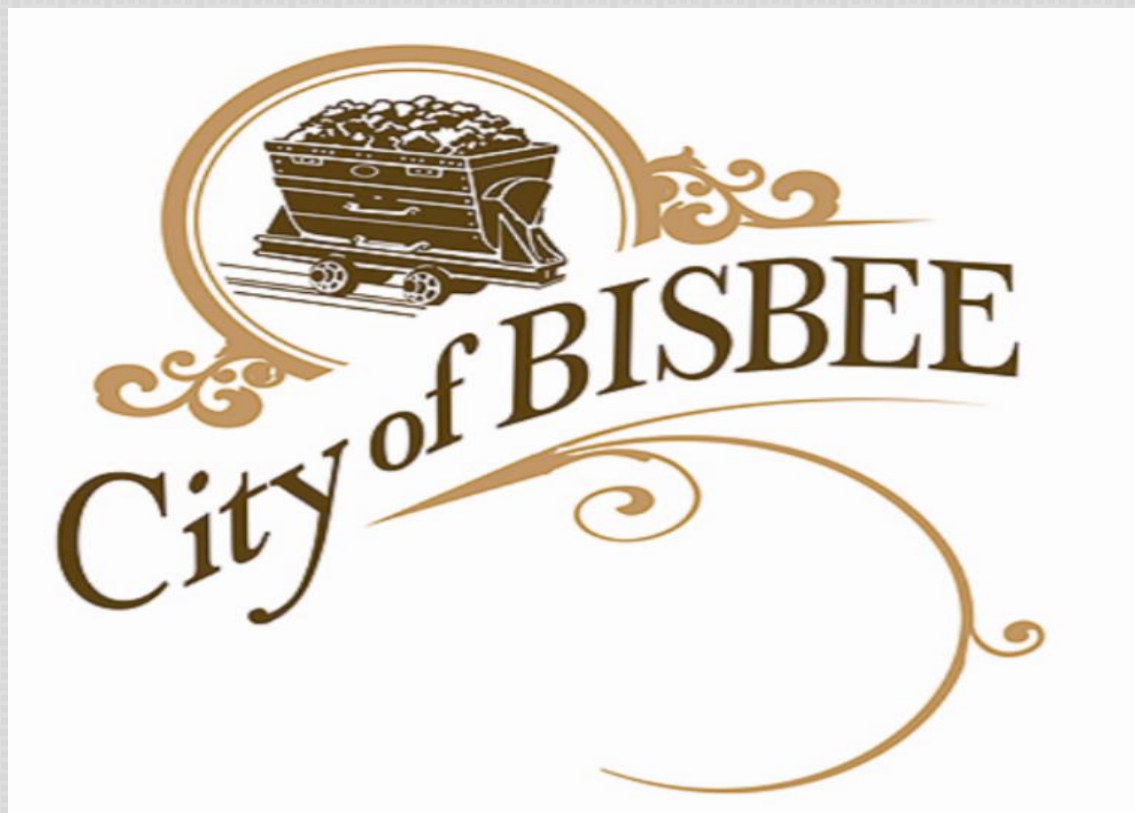
6 months

Inspection and
commissioning

2 months



Enjoy
Solar
power
forever



**ENJOY 100% CLEAN ELECTRICITY
FOREVER**